SENSORY AIDS

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Fabrication of Obstacle Detectors for the Blind

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User Acceptance

In August 1971, eight C-4 canes were given to eight blinded veterans for use after appropriate training. As of this report, all eight veterans still wish to retain their canes. Five out of the eight use them continually; the other three changed their travel patterns so that they only use any mobility aid on an intermittent basis, and at the times when they use any aid, they choose the laser cane.

Reliability

After approximately 4 years of heavy use, following very extensive modification, the canes are still functioning well enough to be of value to their users, though the repair rate is higher than it would be for a cane designed specifically for steady use. The average time between repairs is approximately 2 months; this repair rate has held up for 10 canes for a period of 1½ years.

Design of the New Model C–5 Cane

The contract year was spent redesigning the Model C–4 cane, discussed above, to incorporate a series of features discovered to be useful and to make the cane much less expensive and much more reliable for regular use. The first of the new Model C–5 canes was completed at the end of January 1973. The major changes can be described as being in one of five categories: general, optics, batteries, output stimulators, and electonics.

General

The most obvious change has been in the weight and diameter of the cane. The new cane weighs just a little over 1 lb. (the exact weight

depends upon the nature and length of the staff) and has a diameter of 1 in. through the entire top section instead of 1¼ in. tapering down to 1 in., as was the case in the C–4 cane.

To increase ruggedness, all but one joint has been eliminated, which also tends to make the cane more waterproof.

The tone generator has been relocated from the back of the crook, where the sound radiated down to the pavement and was reflected back to the user's ear, to the curve of the crook, so that it points *directly* at the user's ear. A small port with a series of holes lets the sound emerge through a special material porous to air but not to water.

The stimulator has also been moved up towards the crook approximately ¾ in., to accommodate users with smaller hands.

The switches and controls have been relocated for increased reliability and protection in case of droppage and for increased ease of operation.

Attention has also been paid to the problem of weather resistance.

Finally, both the upper and the lower lens housings have been made significantly smaller, thus making the cane less "electronic" in appearance.

A great deal of effort has gone into improving the performance of the lower (step-down) channel. A more powerful laser was employed so that we would have more concentrated light to start with; then, smaller, sharper optics were installed to produce a sharp beam at approximately the same light level as in the C–4 cane. Much effort was expended to cut down all stray light that would tend to make the beam larger in practice than in the design criteria.

The reason that high optical precision in the handling of the light train is required in this channel is because the downward channel operates by noting the brief "shadow" cast by the curb as the source and receiver "look" at the curb area from slightly different angles. It is thus necessary for the beam to completely disappear from the view of the receiver for a downcurb to be "shadow-detected." The problem is usually helped somewhat by the fact that the street is frequently very dark, while the sidewalk is light, but we must design for the reverse situation also.

Since the ratio of reflectivity of white concrete to black asphalt covered with water is approximately 300:1, 0.3 percent light return will be enough to cause the curb detector to fail under these conditions. Thus, less than 0.3 percent of stray light can be tolerated beyond the central beam. This result was achieved, making it possible to operate the curb detector reliably for a 6-in. curb, with materials varying in reflectivity over the range quoted above.

This still does not eliminate false alarms from highly polished, reflective, dark-colored surfaces, such as highly polished black linoleum or highly polished black terrazzo floors. By accepting a somewhat higher

minimum curb height—say, 8 in.—the range can be extended to include these surfaces also, but we have not yet decided which is the best compromise.

Occasionally, a situation has occurred with the C–4 cane in which a light-colored nearby wall has produced enough reflection from the lasers operating forward or upper channels to return light into the lower channel, even though there is a down-step immediately in front of the wall. This situation has sometimes occurred in a short stair well with light-colored walls around it, for example. To avoid this, we have redesigned the laser and gating system so that the lower channel is turned on alone; then the upper and middle channels are turned on together. Thus the light coming from the upper and middle channels does not affect the lower channel.

We have also installed somewhat more powerful lasers in the upper and middle channels, so that in production we can adjust all canes to have the same power, and thus more nearly the same performance. The overall radiated power, however, will not exceed the maximum power quoted for the C–4 canes; it is only that the C–5 canes will be more uniform than the C–4.

New nickel-cadmium batteries were found, which were smaller enough in diameter than the batteries used in the C–4, to allow reduction of the cane diameter from 1¼ in. to 1 in. Each cell, however, is a little longer than the earlier cells, so that the volume of the new cells is approximately the same as that of the old cells, leading to about the same energy storage per cell as in the C–4. However, the whole system has been redesigned to operate on 6 v. instead of 12 v., thus cutting the weight, size, volume, and energy storage of the new batteries in half as compared to the old. If all of the circuitry were kept the same, this would then cut the time between charges from 5 hours to 2½ hours on the C–5; however, because of some increased efficiencies in the electronics, the average time between charges seems, in practice, to be about 3 or 4 hours. It then takes 6 to 8 hours to recharge. The reason for the variable charge time is that a fair amount of power is used in operating the audio and tactile stimulators; thus, battery life depends upon the length of time these units are actually on.

The assembly of cells has been molded into an arc of a circle that fits inside the cane crook from the end of the crook. The battery is replaceable in the C–5 cane, so that a second battery can be inserted if the first battery has been discharged. Also, when the battery finally wears out (the lifetime is estimated at 1 to 2 years), installing a new battery is not a factory operation, as it was with the C–4.

The tactile stimulator is essentially the same as it was on the C-4 cane, except that the internal mounting has been redesigned so that it can be installed for either left-handed or right-handed use.

The audio sound generators, however, have been changed from piezoelectric to electromagnetic. Since the design of the C–4, a very small, efficient electromagnetic transducer has been designed by Knowles Electronics, Inc. the transducer has higher maximum intensity and broader frequency range than the barium-titanate crystal used before.

As stated in "General" above, this pair of sound generators has been mounted in the curve of the crook, so that the sound will beam directly towards the user's head. In the C–4, there was confusion whenever more than one tone was being sounded at the same time, because the poor frequency response of the transducer caused inadequate tonal separation. With the two electromechanical stimulators, two or more tone signals can be more effectively separated. The upper channel is connected to Stimulator A, which operates at approximately 2,000 Hz. The middle channel is connected to Stimulator B, driving it at about 700 Hz. The down channel drives both stimulators at the same time at about 400 Hz. The frequency response was sufficiently poor at this low frequency that it seemed well to use both stimulators. Furthermore, the likelihood of a down-step signal combined with either of the other two signals is lower than the probability of the upper and middle signals appearing simultaneously. As in the C–4, the low-pitched signal has been made into a rasping sound by adding considerable harmonic content to it, while the other two signals have been made more "piercing" by having them be pure sine waves.

The cumulative result is a louder, less ambiguous, and easier-to-learn tone-signalling system than the C–4 possessed.

The electronics were extensively revised, both in terms of physical layout, to fit on the new boards and to reduce electrical cross-talk between channels, and in performance, in order to increase efficiency and reduce the number of transistor and resistor styles required. The laser pulse drive circuit was made appreciably smaller and less complicated, and a new, smaller pulse transformer was found, which did not exist commercially at the time the last circuit design was made. Both the amplifier power-supply and the laser-drive power-supply circuits are now regulated. to be relatively independent both of battery voltage and of temperature.

Research on Audible Outputs of Reading Machines for the Blind

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Introduction

The research work being carried out at Haskins Laboratories is directed toward the production of a High Performance Reading Machine

for the Blind which, at least initially, will provide a service within an established library setting. A blind person who needs a spoken version of a printed text will apply to the Library's Reading Center and will, in turn, receive a machine-generated tape recording of the text in clear, audible synthetic speech. Such tapes will be available to the blind subscriber in merely a matter of hours, as compared with the long delays that often occur in the recording of texts by human speakers.

Status of the Research

At the present time sufficient progress has been made to state that, from the purely technological viewpoint, the automated production of speech from printed text is wholly feasible. Indeed, a prototype system exists at Haskins Laboratories. This system is continually undergoing refinement to increase its production capacity and to reduce the manual intervention that must now occasionally be made. However, although these refinements are important, and although work is still being devoted to making improvements in the quality of the speech, the time has now arrived when it is prudent to look forward to the eventual deployment of a machine and to confront some of the questions that will then inevitably arise.

It is clear at the outset that the proposed development of Reading Centers for the blind raises many complex questions, from which two emerge as being dominant: 1. How acceptable will automatically produced synthetic speech be to the blind reader at its present level of quality? 2. Where can the resources be found to support the costs of providing a reading-machine service? Although both of these questions deserve parallel attention, tests to assess the acceptability of synthetic speech are crucial prerequisites to the ultimate success of the applied research. Therefore, during the 6 months covered by this report, active efforts have been underway on the problem of evaluating the performance of the prototype reading system by measuring its intelligibility and comprehensibility to listeners under experimentally controlled conditions.

Steps in the Automated Reading of Text

The production of synthetic speech from printed text involves a number of distinct steps. In summary, the information on the printed or typewritten page must be converted into an alphanumeric-magnetic tape by an optical character recognizer (OCR). The tape is then read into a computer, where it is converted from conventional spelling to phonetic spelling. Stress and intonation marks are then assigned, control parameter values are computed for the revised phonetic text by means of the Haskins synthesis-by-rule program, and, finally, these control param-

eters operate a hardware synthesizer that generates a spoken version of the original printed text. These procedures were described in greater detail in BPR 10–17 Spring 1972, pages 254–257.

Effort has continued during the current report period on the development of programs that will enable substantial quantities of synthetic speech to be generated for evaluation purposes. As a result of this work, it is now possible to enter orthographically coded text into the computer and automatically convert that text into phonetic form ready for the speech-synthesis program. The latter routine has been in use for several years. The next major step toward a full-fledged reading machine capable of reading printed text will be the addition of an OCR. The following paragraphs review the progress made on each stage of the production process.

OCR Equipment

With funds granted by The Seeing Eye Foundation, the project has purchased a Cognitronics System/70, which is expected to arrive at the end of January 1973. This machine will read material which has been typed on separate pages with an OCR typeface, convert it into computer-readable form, and thus provide the texts needed for evaluation purposes. To read books already in print, a more versatile recognition machine will eventually be needed, but the cost is likely to be considerably higher than that for the System/70. In the meantime, the performance of the Cognitronics machine should be adequate to meet the demand.

Conversion from Alphabetic to Phonetic Spelling

A fully operational version of a program which converts pre-edited orthographic text into phonetic text is now in use. This routine, using a stored dictionary containing about 150,000 entries, inputs text words from the OCR output into core memory and, word by word, searches for the corresponding phonetic spellings and stress tags. These tags are then used in conjunction with local context rules. The original punctuation marks are also used to supply intonation patterns. Words which are not found in the dictionary are transferred to the output, flanked by special identification symbols which draw the attention of an editor. It is the responsibility of an editor to insert the correct phonetic spelling before synthesis and to update the dictionary as well.

Stress and Intonation

The major rules of stress assignment have been completely incorporated into the computer program for speech synthesis-by-rule. Other rules, such as those depending on the capitalization of words, hyphenization, or on a context of more than two words, will be included in the

program only after there has been more testing of their efficiency. The present computerized stress-assignment method produces quite reasonable perceptual effects without the use of any parsing procedure, and is based on the hypotheses that the semantic weight of words in normal sentences is predictable, and that the semantic weight and prosodic reflex are correlated.

The intonation (by rule) of some prepausal syllables is still noticeably unnatural. Final syllables, in which most or all of the consonants are voiceless (those containing certain vowels and some syllables that are unstressed), seem to be among the most difficult to synthesize successfully. In an endeavor to correct this weakness, additional allophonic adjustments are under study.

Speech Synthesis

A recent revision of the speech synthesis-by-rule program now makes possible the generation of speech from phonetic input without any perceptible computational delay, regardless of the length of the sentence to be spoken. In fact, the efficiency of the program has been increased to such an extent that, with an appropriately adjusted synthesizer, speech could be generated at a rate faster than real time, recorded on a magnetic tape moving at a proportionally faster speed, and later replayed by the blind listener at a normal speaking rate. These improvements in the synthesis program will make it possible to use such a system to provide an audio recording of a requested book in a small fraction of the time that it takes a human reader to read the same pages aloud.

An independent parameter of synthetic speech, not to be confused with its production speed, is the final speaking rate. The original rules in the speech-synthesis program produced optimal synthesis at word rates in the 120–150 word-per-minute range. Blind listeners, however, would like to read considerably faster. It is a simple matter to (linearly) speed up the output word rate by computer (without changing the present phoneme and allophone rules), and the results are quite satisfactory. Nevertheless, fast *natural* speech reduces the durations of *some* syllables in *some* words (and word types) nonlinearly. Accordingly, research proceeds toward further rules appropriate for generating rapid, natural-sounding synthetic speech.

Progress on the Evaluation of Synthetic Speech

Data from a modified Fairbanks Rhyme Test have been gathered on 30 sighted students at the University of Connecticut. This test, which was administered in natural speech as well as in synthetic speech, required the listener to identify isolated words selected from groups of six rhyming words. The students responded by selecting and circling in

pencil a word from each group which resembled most closely the word that they had heard. Three hundred monosyllabic test words were used in six different orders of presentation. A shorter test, consisting of two different presentation orders, was administered to six blind students. These subjects repeated the words that they heard to a sighted student who recorded their responses. In this form, the test posed a slightly more difficult task for the listener, who had no knowledge of the six word groups from which the words he heard were selected.

The analysis of the data collected from these tests is currently in progress. Preliminary indications are, however, that initial consonants were the most frequently confused elements in synthetic speech, and that the frequency of these confusions exceeded those which occurred in natural speech. The proportion of final consonant confusions for synthetic speech were relatively lower when compared with natural speech. Confusion matrices will be constructed and analyzed when the full data on phoneme errors have been tabulated from the response sheets. It is expected that the most valuable information will emerge from an examination of the phonetic contexts in which these errors occur, because this will point to improvements which must be made to the allophonic rules.

Further evaluation tests employing monosyllabic "nonsense" sentences are currently being administered to college students. The results of these tests should be forthcoming in time for the next report.

Papers and Publications

The Haskins Laboratories research, sponsored by the Veterans Administration, was described in two papers that were presented at the 1972 Carnahan Conference on Electronic Prosthetics, September 21–23, 1972 at Lexington, Kentucky, and in one paper that was presented in the 25th ACEMB Conference, Oct. 1–5, 1972.

1. "Automated Reading Service for the Blind," by J. Gaitenby, G. Sholes, T. Rand, G. Kuhn, P. Nye, and F. Cooper.
2. "Selected Research, Development, and Organizational Needs to Aid the Visually Impaired," by P. Nye.
3. "Textbooks in Synthetic Speech: First Evaluation by Blind College Students," by P. Nye, J. Gaitenby, and J. Hankins.

The Development and Evaluation of a Personal Reading Machine for the Blind

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In the period from July 1972 through December 1972, Mauch Laboratories concentrated on improving the Stereotoner. The most significant

improvements were made in the design of the optical probe. Changes in the probe cam tubes and the lens holder eliminated a slight out-of-focus condition at one end (3.16 × reduction) of its 10:1 magnification range. In July, modifications made in the interior design of the clamshell reflector were successful in reducing a central peak in brightness and in producing uniform illumination over a greater height (.800 in. as compared with .750 in.). The outside of the reflector was reshaped to fit the base better, a boss was provided for the lamp-mounting hole, and a series of anti-reflection steps were added to the upper half of the clamshell reflector, near its mouth.

The second Stereotoner prototype, the first one to use the improved optical probe described above, was placed in service at the end of November 1972. Three Stereotoner users (Lauer, Butow, and Bennett) read with it and agree that substantial improvements had been made in the Stereotoner's performance, due mainly to the new probe. There were no complaints or suggestions for improvements. The optical probe originally used with the first Stereotoner prototype was replaced by a probe of the new design with similar favorable results.

In December 1972, changes in the shape of the helical cam slots in the two Stereotoner optical-probe tubes eliminated the binding tendency, as the magnification control was adjusted over one part of its range. This modification also made it possible to eliminate the Teflon previously required between the tubes. The first probe with these changes was used successfully with the third Stereotoner prototype assembled at the end of the month.

Plans were made to a build a fourth Stereotoner prototype, which will incorporate all the improvements to date and which will be as nearly like production units as possible. Production quantities currently under consideration include 50 Stereotoners for the Prosthetic and Sensory Aids Service of the Veterans Administration, 15 Stereotoners for the Committee on Prosthetics Research and Development of the National Academy of Sciences, and 20 Stereotoners for sale to private individuals or other organizations. The commercial sales price of $1,020, f.o.b. Dayton, includes a tracking aid, battery, and charger.

A sound and color movie which explains the function and use of the Stereotoner was completed during this report period. It includes an introduction by Dr. E. F. Murphy, Chief, Research and Development Division, PSAS, Veterans Administration, New York, animation of the Stereotoner operation, and a Stereotoner demonstration by Mr. Lauer of the Central Blind Rehabilitation Center, VA Hospital, Hines, Illinois.

The Stereotoner patent application was prepared in December 1972 and filed on January 8, 1973.

No changes were made to the improved Cognodictor breadboard during this period, in order to devote full time to complete the Stereotoner development as rapidly as possible. A number of new semiconductor devices, read-only memories, and self-scanned photocell arrays were announced by manufacturers and studied for possible use in the Cognodictor. These studies of currently available devices indicated that the technology needed to make a self-scanned array for the improved Cognodictor exists at several companies. A decision to develop electrical and mechanical specifications for the Cognodictor photocell arrays and to solicit proposals from these companies was made in December 1972. As soon as possible, drawings and other specifications will be prepared.

During November 1972, one of the 52 automatic white-level circuits in the improved Cognodictor breadboard began malfunctioning. Due to excessive leakage current in a diode, the circuit's output drifted rapidly toward the black level after being reset. The diode was replaced and normal operation resumed. When self-scanned arrays of phototransistors are available, this part of the Cognodictor will be less complex, thus reducing the chance for component failure.

Reading and Mobility Aids for the Blind, Centrally Directed Clinical Application Program

Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Ill. 60141
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During the period covering activities from July 1, to December 31, 1972, the Hines VAH O/M Research Team conducted two 5-week Training and Evaluation Courses for the Binaural Sensory Aid (BSA), and the team trained four blinded subjects to use the device (one subject has not completed his training). These courses were held from July 3 to August 4, and from August 7 to September 8, 1972. Thus far, some 10 subjects have been trained to use the BSA at Hines since the inception of the project, and most of the subjects are currently involved in the post-training followup program. The 10 subjects received an average of 48.9 hours of training during their participation in the 5-week course. Three of the 10 subjects terminated their participation in the BSA Evaluation Project during their followup periods. Plans are under way to conduct two or three more training courses for the BSA during the spring and summer of 1973.

Mr. Farmer was invited to give a lecture on "Electronic Mobility Devices for the Blind" on the occasion of the Annual Fall Conference of the Michigan Student Council for Exceptional Children, held at Michigan State University, East Lansing, Michigan, on September 29, 1972.

The Conference was sponsored by Student Chapter No. 572 at Michigan State University.

Mr. Farmer and Mr. Whitehead presented papers at the Conference on the Development of Mobility Aid Evaluation Procedures, which was sponsored by the Subcommittee on Sensory Aids, Committee on Prosthetics Research and Development, NAS/NRC. Mr. John D. Malamazian, Chief of the Central Rehabilitation Section for Visually Impaired and Blinded Veterans, was Chairman of the Conference, held at the Illinois Visually Handicapped Institute, Chicago, Illinois, on November 13–14, 1972.

During the period between September 21, and November 29, 1972, the Hines VAH O/M Research Team had conferences with Forrest M. Mims, inventor of the Seeing Aid (an infrared miniature electronic guidance and object-detection system for the blind); with Russell Smith, Manager of the Sonic Division of Viligant, Ltd. (the Company that manufactures the Kay Binaural Sensory Aid in Christchurch, New Zealand); with Lindsay Russell, inventor of the Pathsounder, and George F. Dalrymple, Director, Sensory Aids Evaluation and Development Center, Massachusetts Institute of Technology, Cambridge, Massachusetts; and with Dr. Derek Rowell, Research Associate, Division of Special Education and Rehabilitation, Boston College, Chestnut Hill, Massachusetts, and E. W. Bensemann, Company Manager of Vigilant, Ltd., Christchurch, New Zealand.

The last stage of the C–4 Laser-Cane Evaluation, which was jointly conducted by the VAH, Palo Alto, and VAH, Hines, research teams, was concluded with the second on-site visitation. The eight subjects ended their 9 months participation in the followup program in their home communities. In addition to an open-ended interview and a questionnaire given to each subject, video tapes were made of their travels in familiar and in unfamiliar areas with their conventional Long Canes and with the C–4 Laser Canes. The video tapes were later viewed, and the subjects' orientation and mobility performances were rated by eight O/M Specialists at each of the two VA Blind Rehabilitation Centers. The final meeting of the Advisory Panel for the Preliminary Evaluation of the Bionic Instruments—Veterans Administration C–4 Laser Typhlocane was held at Hines VAH on November 15, the purpose of which was to review the data retrieved from the followup program and to plan the reporting of the findings. A report of the complete study is currently being drafted by the panel for presentation to the National Academy of Sciences.

Several evaluation procedures developed for the study appear to hold promise for the future and seem to merit further consideration for future investigation and refinement. The video recording of mobility performance, and the subsequent use of the video tapes in a clinical setting,

would appear to be very useful evaluation tools. An Orientation and Mobility Task Rating Form, which the 16 O/M Specialists used to rate selective tasks and the total mobility performances of the subjects, was generally received well by the raters. The objective recording of several critical events of travel performance using an Orientation and Mobility Subtask Checklist Form also merits future consideration and development.

Clinical Trials of Reading Machines for the Blind
Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Ill. 60141
John D. Malamazian and Harvey L. Lauer

This project incorporates teaching and evaluation of reading aids for the blind. Many new developments in hardware have caused the need for testing and preparation for the evaluation of aids.

Two Stereotoner prototypes were used by Mr. Lauer and by other reading-aid users. The probe was then redesigned by Mauch and retested by them. An extensive evaluation is being planned. The Stereotoner uses a binaural code and many features derived from experience with the Visotoner.

In October, Mr. Lauer took a 2-week course in using the Optacon at the Cleveland Society for the Blind. Since then, he has practiced reading with it and has partly taught the skill to three persons, two of whom are teachers at this center and are now in the training program.

Mr. Lauer was sent on several other trips. In July he went to California to work with his counterpart, Richard Bennett, reading specialist at the Western Blind Rehabilitation Center, Palo Alto, and to demonstrate reading aids at the convention of the Blinded Veterans Association in Los Angeles. Also in July, he demonstrated reading machines at the convention of the National Federation of the Blind in Chicago.

In September, he spent a day in Dayton at Mauch Laboratories to help in the making of a movie on the Stereotoner. In December, in Washington, D.C., he participated in a National Academy of Sciences, Sensory Aids Subcommittee panel on the evaluation of ink-print readers.

M. Lauer has also worked with the Varispeech-I, a tape recorder with an electronic processor for compressing speech. Several long recordings of compressed speech were made and duplicated. They were shared with a number of those interested in the use of the machine, and some data were gathered. Mr. Lauer has also learned to use the Kay binaural sensory aid for mobility.

Mr. Lauer wrote two papers for use in the field-tools and supplies needed for Optacon and Stereotoner teaching, and a report on a proposed audible Optacon code. A report is being prepared on the value of the several tracking aids concerning their usefulness in various stages of training and in the use of reading aids.

Development of Correspondence Courses for Personal Reading Aids for the Blind

The Hadley School for the Blind
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From July 1 through 8, 1972, the Stereotoner was demonstrated at the convention of the National Federation of the Blind held in Chicago. During the convention, about 90 members of the Federation came to The Hadley School for a tour. One of these had just completed the Visotoner Screening Course with a grade of "A," and she was presented a certificate of completion. The first 2 weeks in October, she came to The Hadley School for training with the Visotoner. The Iowa Commission for the Blind paid her travel and living expenses while she was here. She is a typist who operates the IBM/MTST typewriter. She used the Visotoner with two earphones, reading 70 Battelle course lessons, plus part of a letter from another student, and a letter that her husband had typed. She was loaned a Visotoner for a year, and with the help of the Iowa Commission for the Blind, hopes to obtain a Stereotoner when they become available. She hears the code well, and has little trouble scanning the print and changing lines. She has subsequently sent one tape of her reading. She uses the Visotoner for checking her typing and to read her office newsletter.

Another student continues to use the Visotoner, developing skills in reading without the tracking aid and adjusting for different sizes of print on bulletins, such as the AAWB Newsletter.

Two days in November were spent at Hines Rehabilitation Center learning to use the Optacon. No proficiency has been gained with it, but simple material can be deciphered. It was found that after some practice, long periods of reading could be done without getting a sore finger.

On December 1, there was a conference on reading-machine evaluation sponsored by the Subcommittee on Sensory Aids of CPRD, National Academy of Sciences. The consensus was that the American Institutes for Research, which is currently developing teaching materials and working with several blind subjects using the Optacon, make a similar proposal to do the same kind of evaluation for the Stereotoner. The proposal would be made to the Veterans Administration. The Visotoner Screening Course will be revised and recorded in stereo. The Hadley

School may be involved with other aspects of the program such as teaching the reading-machine skill to others.

Mobility and Reading Aids for the Blind, Centrally Directed Clinical Application Program
Western Blind Rehabilitation Center
VA Hospital
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Loyal E. Apple, Richard Bennett, William Ekstrom, and Donald C. Cooper

During July 1972, the final followup for the Bionic C–4 Laser Cane was conducted on the last subject. This consisted of an interview and the video taping of the subject traveling over familiar and unfamiliar routes with laser and long canes. Copies of the video tapes of the four subjects trained with the laser cane at VAH Palo Alto were sent to VAH Hines, Illinois, and they, in turn, sent to Palo Alto video tapes of their four subjects in travel. The video tapes were reviewed by eight Orientation and Mobility Instructors at the VAH Palo Alto, with each instructor viewing four travel tapes. The instructors rated each tape on 17 aspects of travel. The same review of all the video tapes was conducted at the VAH, Hines. In addition to this, a second rating of the video tapes was conducted by each station on the tapes recorded at that particular station. This rating was done by the instructors who had trained the laser-cane users. With the video tapes and a tape-recorded commentary made by an observer at the time of the video taping, 53 subtasks critical to orientation and mobility performance were scored. These subtasks were objective incidents that could be answered with either a numerical tally or a "yes/no" answer. All of the data from these ratings was brought together at a meeting in November of the Advisory Panel for the Evaluation of the Laser Cane. The Orientation and Mobility Instructors at Palo Alto and Hines, who trained the laser-cane users and carried out the followup activities, are members of this panel. Additional data and material from the training phase were also on hand. The formulation of the final report was discussed, outlined, and specific task assignments were issued. Presently the report on the training and field evaluation of the eight Bionic C–4 Laser Cane users is being drafted.

Mauch Laboratories' new Stereotoner was introduced in May 1972. Activity during the subsequent period focused on this device. Mr. Richard Bennett, Western Blind Rehabilitation Center, and Mr. Harvey Lauer, demonstrated the new reading aid at the Blinded Veterans Association Convention in Los Angeles, California, July 19–21, 1972. Mr. Bennett used the prototype extensively between July 16 and August 16,

1972. He reported his observations to the Research and Development Division PSAS, and to Mauch Laboratories.

Mauch Laboratories made several improvements on the prototype and returned it to Mr. Bennett on December 1, 1972. The modifications had eliminated most of the problems and drawbacks. A brief trial of the Stereotoner Prototype #2 led to the conclusion that this was definitely superior to the revised Prototype #1.

Mauch Laboratories had not completed the tracking aid they had planned for the Stereotoner. Because of the desirability of using a good tracking aid with the Stereotoner, Neil Greiner, Western Blind Rehabilitation Center, was requested to design and build an adapter which permitted use of the Mauch Colineator with the Stereotoner. Mr. Greiner has also designed and developed an adapter which allows use of the excellent Mauch Colineator with the T.S.I. Optacon camera.

Mr. Bennett, along with Miss Margaret Butow and Mr. Lauer, attended a meeting of the Panel on Evaluation of Ink-Print Readers in Washington, D.C., on December 1, 1972. They served as consultants to the panel, which functions within the framework of the Sensory Aids Subcommittee, Committee on Prosthetics Research and Development, National Academy of Sciences.

Mr. Bennett had an additional Visotoner student from December 14–19, 1972, a 38-year-old veteran who had completed only the first few Hadley Visotoner Screening Course lessons. After approximately 25 hours of instruction, he had acquired the basic skills needed to read with the aid. He read an intermediate-level Battelle reading test at the rate of 11 words per minute, with excellent legibility, reading for 31 minutes without interruption. This veteran was allowed to return home with a Visotoner and will be followed up in the usual manner, with regular telephone and taped contacts. He may return during 1973 for Stereotoner instruction.

Development of Test Procedures for Evaluation of Binaural Hearing Aids

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The main activity during this report period has been directed toward an evaluation of the hearing aids maintained in the Northwestern University Medical School Hearing Clinic. During the past year, this hearing clinic maintained a hearing-aid inventory consisting of 84 models of 12 brands of instruments. Records from all selection-of-hearing-aid appointments completed during the past year were reviewed recently; a tally was made of the number of times each make and model

of hearing aid was tried and the number of times a particular make and model of instrument was recommended. From these tallies, we have selected 16 instruments which were tried at least 14 times and which had recommendation rates ranging from 12 percent to 62 percent. Preliminary study of some of the features of these instruments quickly revealed that the seven instruments recommended most frequently were units having internal controls for adjusting the frequency-response characteristics, maximum power output, etc. This observation suggests that the capability of altering performance characteristics of these instruments allows them to be adapted to various types and patterns of hearing losses, thereby making them the more useful instruments in the inventory. At the present time, measurements of gain, frequency response, maximum power output, harmonic distortion, and intermodulation distortion for these 16 instruments are being completed. Determination is being made as to whether or not results from one or more of these measurements of physical performance characteristics will demonstrate differences among these instruments which might explain, at least in part, the marked differences in the frequency of recommendation of the 16 selected instruments.

Influence of Input and Gain Values Upon Electroacoustic Properties of Hearing Aids

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Research and development on hearing aids conducted by manufacturers have led to instruments with characteristics not measureable by the current methods of evaluation. A present concern of this laboratory is the development of a more realistic method for describing the physical performance of CROS, BICROS, and hearing aids with directional properties. At the moment a mannequin, which provides average anthropometric dimensions, will be mounted on a revolving turntable in the anechoic chamber. Various hearing aids can be attached through a Zwislocki coupler. The advantage of measurements of hearing aids placed on the mannequin will be a better approximation of their performance in real life on the hard-of-hearing subject. Some technical difficulties will have to be overcome and procedures developed for the actual measurements.

In conjunction with the above physical measurements, a preliminary investigation into the use of the directional microphone in behind-the-ear hearing aids with a clinical population is in progress. The purpose of this study is to determine if the directional qualities of the microphone

in two different aids improve the speech-discrimination ability of hearing-impaired listeners. Subjects are seated in a sound-treated room, equidistant between two loudspeakers. Speech signals are presented from the loudspeaker facing the subject, and noise is presented from the rear loudspeaker. In addition to the evaluations with the two-directional microphone aids, each subject performs the speech-discrimination task wearing one aid with a regular front-facing microphone and one aid with a regular rear-facing microphone. Speech-discrimination scores using each of the four hearing aids will be evaluated and compared to determine if any significant differences in performance are present.

In a study of VA audiologists' uses of hearing aids for fitting impaired listeners, over 500 hearing-aid wearers were examined for severity of hearing impairment. The classification of these impairments was based on the unaided speech-reception threshold (SRT) for the ear fitted with an aid. The categories of hearing impairment (ISO, 1964) included: 1. SRT's less than 30 dB, 2. SRT's between 30 and 49 dB, 3. SRT's between 50 and 69 dB, 4. SRT's between 70 and 84 dB, and 5. SRT's of 85 dB or greater. The results from more than 500 hearing-aid wearers showed that 17 percent could be classified as having mild hearing impairment, 35 percent had mild-to-moderate impairments, 34 percent had moderate impairments, and 9 percent had profound impairments. Other aspects of hearing-aid wearers are now under investigation.